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THE USE OF STATISTICAL SAMPLING IN CONTRACT PRICING

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DEAN OF THE FACULTY
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Philip J. Erdle

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Vice Dean of the Faculty

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This report provides the reader with the results of a study on the use of statistical sampling techniques on pricing cases in one Air Force Plant Representatives Office (AFPRO). The study reveals that 38% of the AFPRO pricing workload is devoted to 1½% of the contractual dollars and that 77% of the workload is devoted to 11% of the dollars proposed. This study was undertaken to help the AFPROs concentrate their skilled manpower on the large dollar proposals by using statistical sampling on backlog proposals under $100,000. Data was collected at one AFPRO for all pricing cases for a

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20. ABSTRACT (Cont'd)

three-year period, and sampling variations (sample sizes, dollar magnitude, etc.) were tested to determine the feasibility of the concept and the appropriate sample size and dollar limitations. The report concludes that for the subject AFPRO, using 25% sample size of backlogged cases less than $100,000, the analyst can be highly confident that the average percentage reduction recommended for the sample does not statistically differ from the reduction with 100% pricing. Additional data were collected to test the 25%, $100,000 conclusion, and the results supported the initial finding. This report should prove to be invaluable for AFPRO and Defense Contract Administrative Services (DCAS) offices dc'ng repetitive pricing from the same contractor under backlog conditions.

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BACKGROUND

In every DoD-negotiated procurement action, some form of price or cost analysis is required. The method and degree of analysis, however, is dependent on the facts surrounding the particular procurement and pricing situation. The extent of this analysis should be that effort necessary to assure reasonableness of the pricing result, taking into consideration the amounts of the proposal, and the cost and time needed to accumulate the necessary data for analysis.

The Armed Services Procurement Regulations (ASPR) authorize field-level contract pricing and negotiations between contractors and government Administrative Contracting Officers (ACOs) assigned to resident offices of the Air Force, Army, and Navy (where plant cognizance has been established) or to Defense Contract Administration Services (DCAS) offices. The contractual actions that are normally assigned to the field ACO are the following: (1) definitizing changes under a prime contract when so authorized by the contracting officer in the System Program Office (SPO); (2) negotiating provisioned items of prime contracts such as spares; and (3) preparing basic ordering agreements. When the ACO is so charged with one of these responsibilities, the contractor submits his detailed costs and profit proposal to him, a price analysis is performed, negotiations are conducted, and a contract or supplement agreement is executed. For those contractual actions retained by the SPO, the ACO forwards the field price analysis along with his recommendations to the SPO for further analysis, negotiation, and final contractual action.

One of the primary functions of the price analyst is to act as the proposal evaluation team captain, responsible for coordinating and consolidating all inputs into a unified government position. These duties usually start with his preliminary review of each contractor proposal's contents. The analyst then determines if the proposal complies with the established contractor estimating system, and decides if the proposal structure and content are sufficient to permit the depth and type of evaluation the ACO requires. This review consists of an analysis of all cost elements: the various categories of labor, materials, subcontracts, general and administrative, and overhead, as well as the incentive portions of the profit proposed by the contractor.

The overall proposal evaluation responsibility rests with the price analyst. Depending upon the proposal amount and complexity, the analyst may request technical assistance when manufacturing, engineering, or quality assurance hours are proposed. The quality and quantity of historical data available for reference, as well as the background and qualifications of the assigned price analyst, should also be a consideration in determining the extent of assistance needed. Normally, when the proposal requires evaluation of high technology efforts and new techniques, the inputs of a qualified technical specialist are required. Proposals requiring an analysis of a learning curve, comparison of other past history or hardware of similar configurations, or an extension of current labor standards can normally be accomplished solely by the price analyst. In all cases where time standards form the basis of the contractor's estimate, the methods of applying the time standards and the validity of the performance factors must be evaluated by the techn al specialist.

The price analyst must coordinate the technical efforts, the inputs from the Defense Contract Audit Agency (DCAA), and the overhead division. With this information, supported by his experience and judgment, he puts the final evaluation together, and forwards his recommendations to the ACO.

The ACO then carefully studies and evaluates the report to enable him to negotiate a fair and reasonable price for the government. After negotiations, which are normally supported by the price analyst, the contract is formally modified and the necessary documentation placed in a file. This documentation contains a breakdown of the negotiated price to include labor hours by category, labor rates, materials, subcontracts, overhead, general and administrative expenses, and profit. The complete case file includes this documentation along with document support from other agencies: production, quality assurance, engineering, and overhead divisions, the DCAA resident auditors, and the SPO engineers. A period of sixty days is normally allowed for the proposal analysis and negotiation.

Our examination of this time-consuming process at one Air Force Plant Representative Office (AFPRO) has revealed that a backlog of pricing cases often develops. Since each case must be priced prior to negotiations, this backlog can delay negotiations and subsequent definitization of the change. The intent of ASPR is to negotiate changes as promptly as prudent evaluation of proposals permits, and certainly well before the proposed dollars become actuals. Backlog conditions can cause serious violations of this intent, and most analysts perceive a 60-day deadline to complete pricing cases. The contractor also has some incentive to negotiate these actions promptly, for he cannot receive progress payments on undefinitized work.

With these two pressures to reduce backlogs of pricing cases, it is easy for pricing analysts to spend relatively equal time analyzing cases regardless of the dollar magnitude. Although we have no firm data on the analyst time spent per pricing case, our research has revealed that the time pressures to complete pricing cases are real and most analysts respond accordingly. Our study of one AFPRO has revealed that 38% of the pricing workload was devoted to 1.5% of the proposal dollars, and that 77% of the cases represented 11% of the proposal dollars.

This workload mix and the 60-day deadline system perceived by most analysts have caused us to look for ways to free critical analyst time so that he can concentrate his efforts on the larger proposals that have a greater potential for savings with a more thorough analysis. Wallenius[1] has proposed a system for statistical sampling of pricing cases under $100,000 that would expedite the processing of these smaller proposals and allow the analyst man hours to be reallocated to larger proposals. His report discusses the results of the Naval Air Systems Command use of a sampling system for proposals under $50,000, and assesses the risk confronting both the government and the contractor by such a system.

[1] K. T. Wallenius, "On Statistical Methods in Contract Negotiations, Part II," Office of Naval Research Report, N21, July 1, 1972.

This report, an extension of Wallenius' work, uses data collected from one AFPRO to determine two things: (1) a sample size to yield statistically acceptable results, and (2) to what level of dollar proposals could we most effectively apply sampling techniques.

STATISTICAL ANALYSIS

For the AFPRO price analyst to feel confident about the value of sampling from backlogged proposals, he must believe that the random sample which he selects, analyzes, and recommends as a negotiation position for the remainder of the backlogged proposals is indeed representative of that backlog. Once he is convinced of the value of sampling he must know how large the sample size should be and which populations of proposals should be sampled. To find these answers, we first analyzed the FY 74 and FY 75 workload of one AFPRO. We analyzed a total of 441 pricing cases to determine whether sampling could have been used confidently at this AFPRO during these years. The data collected consisted of the pricing case number, type of procurement action, dollar amount proposed, dollar amount recommended by the price analyst, dollar amount negotiated, and whether there were inputs from engineering, production, quality assurance, or DCAA. Only the data dealing with pricing case number, dollar amount proposed, and dollar amount recommended by the price analyst were subsequently used for analysis in this study.

Hypothesis

If the sample selected is truly representative of the population from which it is drawn then the mean cost reduction (decrement) recommended by the analyst for the sample should not significantly differ from the mean cost reduction (decrement) that would be recommended for the whole population if the analyst had analyzed every one of the contractor's proposals. Therefore, the following hypothesis was tested for the specific AFPRO, utilizing historical data from the 441 pricing cases:

(H_o) For proposals under a specific dollar amount, the mean difference between e contractor's initial proposed cost and the AFPRO's recommended cost for a random sample of proposals (sample mean decrement) is equal to the mean decrement for the population of proposals as a whole in a given time period.

Sample sizes analyzed varied from 10-50% of the backlog, and were selected from a computerized random sampling routine. Appendix E conta a copy of the program written to perform this random sampling.

Test Procedures

The populations analyzed were these: (a) all contractor proposals less than $100,000 in total dollar value, (b) all contractor proposals less than $500,000 in total dollar value, and (c) all contractor proposals less than $1,000,000 in total dollar value. The $100,000 breakpoint for analysis is the most logical one to use because 38% of the pricing cases analyzed fell into this range and were often of a similar nature (i.e., change orders). This is also a logical breakpoint for analysis because backlogs under $100,000 tend to build up and sampling can be of great benefit. An equally significant reason for using that breakpoint is that while ASPR does require a detailed Cost Element Breakdown, it does not usually require a detailed technical evaluation; thus, the price analyst or ACO has more flexibility in determining how the overall analysis will be performed. The $500,000 and $1,000,000 breakpoints were also analyzed to see if the hypothesis was supported for higher breakpoints.

Assuming a normal distribution of differences between the contractor's initial proposed cost and the AFPRO's recommended costs, the t test was utilized to test the hypothesis (H_o) that the sample mean decrement was equal to the population mean decrement. Rejection regions were established from the sampling distribution and the values of α equal to .01 and .05 levels of significance.[2] One hundred different random samples of each sample size were generated from each population. The actual value of the sample statistic was then calculated for each sample and was checked to see if it fell into the rejection region. If the t statistic did not fall into the rejection region then the analyst could be very confident that the sample mean was not statistically different from the population mean. Appendix E contains a copy of the program written to perform the t tests. Table 1 presents the results of these t tests.

[2]For a discussion of confidence intervals and hypothesis testing see William L. Hays and Robert L. Winkler, Statistics: Probability, Inference, and Decision (New York: Holt, Rinehart and Winston, Inc., 1971), pp. 354-358.

TABLE 1

RESULTS OF t TESTS (FY 74-75 DATA)

1. Dollar Value Breakpoint = $100,000 Population Size = 172

Sample Size	α = .01 # Samples Passed*	α = .05 # Samples Passed
10% - 17	99	95
25% - 43	99	98
30% - 51	100	99
50% - 86	100	100

2. Dollar Value Breakpoint = $500,000 Population Size = 291

Sample Size	α = .01 # Samples Passed	α = .05 # Samples Passed
10% - 29	100	98
25% - 72	100	99
30% - 87	100	100
50% -145	100	100

3. Dollar Value Breakpoint = $1,000,000 Population Size = 341

Sample Size	α = .01 # Samples Passed	α = .05 # Samples Passed
10% - 34	95	92
25% - 85	100	100
30% -102	100	99
50% -170	100	100

*Out of 100 random samples tested for each sample size, the number of samples for which the t statistic did not fall into the rejection region.

As evidenced in Table 1, the mean decrement of the random samples of all sizes tested would have provided an excellent indicator of the overall population mean decrement. For example, if a proposal backlog of cases less than $100,000 developed over this period of time, the price analyst could have taken a sample of 25% from his backlog (43 proposals), analyzed it, and recommended what the cost reduction (decrement) should have been. In 99 out of 100 samples tested he would have been 99% confident that the mean decrement recommended for the sample was statistically no different than the mean decrement he would have recommended had he analyzed every proposal in the population. This use of sampling would have reduced his backlog significantly and allowed him to devote more time to the larger dollar proposals.

If this AFPRO had, in fact, adopted a policy of using sampling methods to reduce backlogs of lower dollar proposals when they became excessive, we next asked how well would it have worked over this past fiscal year (FY 76). Since FY 76 was not included in the 441 cases to test the original hypothesis, the FY 76 data were used to determine how well the initial conclusions would hold up over the most recent time period.

Additional Testing with New Data

Additional pricing caseload data were gathered for the past fiscal year at the same AFPRO and a test data base of 63 cases was established. Again utilizing the same hypothesis (H_o) of the equality of the sample and population means, we conducted t tests as with the previous data base. Table 2 presents the results of these t tests. Using a sample size of 25% here, the price analyst could have been 99% confident that the sample mean would equal the population mean in 98 out of 100 samples tested. However, the data base was too small to adequately test sample sizes of 10%.

TABLE 2

RESULTS OF t TESTS (FY 76 DATA)

1. Dollar Value Breakpoint = $100,000 — Population Size = 23

Sample Size	α = .01 # Samples Passed	α = .05 # Samples Passed
10% - 2	87	73
25% - 5	98	95
30% - 6	100	99
50% - 11	100	100

2. Dollar Value Breakpoint = $500,000 — Population Size = 46

Sample Size	α = .01 # Samples Passed	α = .05 # Samples Passed
10% - 4	92	84
25% - 11	99	95
30% - 13	100	97
50% - 23	100	100

3. Dollar Value Breakpoint - $1,000,000 — Population Size = 57

Sample Size	α = .01 # Samples Passed	α = .05 # Samples Passed
10% - 5	98	86
25% - 14	100	97
30% - 17	100	99
50% - 28	100	100

Conclusions Regarding Contractor Proposals

We have shown that, at the AFPRO studied, sampling can be used with a high degree of confidence to reduce backlogs of lower dollar value proposals. As long as the contractor is consistent and follows some basic predetermined algorithm or computer model the situation is ideal for sampling.

It is definitely in the contractor's interest to be consistent in the preparation of his proposals from both organizational control and financial management standpoints. The contractor is better able to centralize control over his organization if his contracting personnel follow a standardized organizational model in building their proposals. From a financial management standpoint, consistency is desirable because it tends to reduce profit uncertainty associated with the otherwise random nature of proposals prepared by different organizational units or individuals with separate goals and objectives. At the AFPRO studied, the contractor used a computerized pricing algorithm that is essentially the same over time with certain cost variables updated as new information about actual cost factors and rates becomes available.

In the event that a particular AFPRO is dealing with a contractor who does not exhibit this pricing consistency over time, sampling is not a valid strategy to consider in reducing proposal backlogs. This is due to the inherent randomness of the proposals and the possible use of gaming strategies by the contractor. Wallenius[3] addressed this potential problem of gaming and provided some possible strategies in the event it is encountered.

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[3]Wallenius, "On Statistical Methods in Contract Negotiations, Part II," p. 11.

RECOMMENDATIONS

At the specific AFPRO studied, statistical sampling methods could be used to reduce backlogs of proposals less than $100,000 in total value and thereby allow the AFPRO to concentrate its skilled manpower on large dollar proposals. Our study reveals that as long as the population size (backlog of pricing cases) from which the sample is drawn is greater than 30, a 25% sample size may be used. Sampling is not recommended with populations of less than 30 proposals. With backlogs of 100 or more proposals, a 10% sample size may be used with confidence (Table 1).

Individual field pricing activities may also consider sampling as a method of reducing backlogs of proposals less than $500,000 or less than $1,000,000. All sample sizes tested yielded excellent results when drawn from backlogs of 100 or more proposals.

We recommend that each field pricing activity analyze its own proposal workload to determine whether or not sampling is feasible for its operation. Sampling probably will not be as successful if the contractor does not submit consistent proposals that are developed with a standardized cost model or algorithm. A form of local system surveillance is necessary when using sampling to insure that the contractor is not submitting inconsistent proposals or proposals involving gaming strategies.

Although this study has shown that sampling can be used confidently to reduce proposal backlogs, it should be remembered that these sampling techniques are intended to be used as a backup procedure. Pricing analysis of all proposals is certainly desirable when possible.

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APPENDIX A

FY 74-75 DATA BASE

VARIABLE DCAA WAS THERE DCAA INPUT?

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO	0.00	186	42.2	42.2	42.2
YES	1.00	255	57.8	57.8	100.0
	TOTAL	441	100.0	100.0	100.0

VARIABLE TYPCON TYPE OF CONTRACT

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
OTHER	0.00	188	42.6	42.6	42.6
FFP	1.00	168	38.1	38.1	80.7
FPI	2.00	31	7.0	7.0	87.8
CPIF	3.00	10	2.3	2.3	90.0
CPFF	4.00	40	9.1	9.1	99.1
CPAF	5.00	4	0.9	0.9	100.0
	TOTAL	441	100.0	100.0	100.0

VARIABLE TYPJOB TYPE OF PRICING CASE

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
OTHER	0.00	9	2.0	2.0	2.0
CONTRACT BID	1.00	82	18.6	18.6	20.6
SPARES	2.00	103	23.4	23.4	44.0
CHANGES	3.00	141	32.0	32.0	76.0
WORK ORDER	4.00	53	12.0	12.0	88.0
SUBCONTRACT	5.00	27	6.1	6.1	94.1
COST GROWTH	6.00	10	2.3	2.3	96.4
TECH PUBS	8.00	16	3.6	3.6	100.0
	TOTAL	441	100.0	100.0	100.0

APPENDIX A (continued)

VARIABLE ENG WAS THERE ENGINEERING INPUT?

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO	0.00	392	88.9	88.9	88.9
YES	1.00	49	11.1	11.1	100.0
	TOTAL	441	100.0	100.0	100.0

VARIABLE MFG WAS THERE MFG OPS INPUT?

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO	0.00	423	95.9	95.9	95.9
YES	1.00	18	4.1	4.1	100.0
	TOTAL	441	100.0	100.0	100.0

VARIABLE QUAL WAS THERE QUAL ASSURANCE INPUT?

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
NO	0.00	438	99.3	99.3	99.3
YES	1.00	3	0.7	0.7	100.0
	TOTAL	441	100.0	100.0	100.0

VARIABLE PERCNT PERCENTAGE REDUCTION RECOMMENDED

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	-16.09	1	0.2	0.2	0.5
	-6.23	1	0.2	0.2	0.7
	-0.45	1	0.2	0.2	0.9
	0.00	5	1.1	1.1	2.0
	1.00	31	7.0	7.0	9.1
	2.00	34	7.7	7.7	16.8
	3.00	55	12.5	12.5	29.3
	4.00	38	8.6	8.6	37.9
	5.00	27	6.1	6.1	44.0
	6.00	29	6.6	6.6	50.6
	7.00	27	6.1	6.1	56.7
	8.00	18	4.1	4.1	60.8
	9.00	17	3.9	3.9	64.6
	10.00	19	4.3	4.3	68.9
	11.00	20	4.5	4.5	73.5
	12.00	20	4.5	4.5	78.0
	13.00	7	1.6	1.6	79.6
	14.00	16	3.6	3.6	83.2
	15.00	10	2.3	2.3	85.5
	16.00	7	1.6	1.6	87.1
	17.00	6	1.4	1.4	88.4
	18.00	8	1.8	1.8	90.2
	19.00	7	1.6	1.6	91.8

PRICING DATA RESEARC 07/16/76

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GT 25 PERCENT	22.00	24	5.4	5.4	100.0
	TOTAL	441	100.0	100.0	100.0

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                  TYPCON,TYPE OF CONTRACT/
                  PROP, SIZE OF PRICING CASE/
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                  QUAL,WAS THERE QUAL ASSURANCE INPUT?/
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                  PNEG,PERCENTAGE REDUCTION NEGOTIATED/
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                  MFG  (0) NO (1) YES/
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IF                (PNEG GT 6 AND PNEG LT 7) PNEG = 7
IF                (PNEG GT 7 AND PNEG LT 8) PNEG = 8
IF                (PNEG GT 8 AND PNEG LT 9) PNEG = 9
IF                (PNEG GT 9 AND PNEG LT 10) PNEG = 10
IF                (PNEG GT 10 AND PNEG LT 11) PNEG = 11
IF                (PNEG GT 11 AND PNEG LT 12) PNEG = 12
IF                (PNEG GT 12 AND PNEG LT 13) PNEG = 13
IF                (PNEG GT 13 AND PNEG LT 14) PNEG = 14
IF                (PNEG GT 14 AND PNEG LT 15) PNEG = 15
IF                (PNEG GT 15 AND PNEG LT 16) PNEG = 16
IF                (PNEG GT 16 AND PNEG LT 17) PNEG = 17
IF                (PNEG GT 17 AND PNEG LT 18) PNEG = 18
IF                (PNEG GT 18 AND PNEG LT 19) PNEG = 19
IF                (PNEG GT 19 AND PNEG LT 20) PNEG = 20
IF                (PNEG GT 20 AND PNEG LT 25) PNEG = 21
IF                (PNEG GT 25)PNEG = 22
CODEBOOK          TYPJOB,TYPCON, PROP, DCAA,ENG,MFG,QUAL,PERCNT
STATISTICS        1,2,3,4
READ INPUT DATA
```

APPENDIX B

FY 76 DATA BASE

VARIABLE TYPCON TYPE OF CONTRACT

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
OTHER	0.00	35	55.6	55.6	55.6
FFP	1.00	21	33.3	33.3	88.9
CPIF	3.00	5	7.9	7.9	96.8
CPFF	4.00	2	3.2	3.2	100.0
	TOTAL	63	100.0	100.0	100.0

VARIABLE TYPIOP TYPE OF PRICING CASE

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
OTHER	0.00	33	52.4	52.4	52.4
CONTRACT RTO	1.00	3	4.8	4.8	57.1
SPARES	2.00	16	25.4	25.4	82.5
CHANGES	3.00	7	11.1	11.1	93.7
SUBCONTRACT	5.00	1	1.6	1.6	95.2
TECH PUBS	8.00	3	4.8	4.8	100.0
	TOTAL	63	100.0	100.0	100.0

VARIABLE PERCIT PERCENTAGE REDUCTION RECOMMENDED

VALUE LABEL	VALUE	ABSOLUTE FREQUENCY	RELATIVE FREQUENCY (PERCENT)	ADJUSTED FREQUENCY (PERCENT)	CUMULATIVE ADJ FREQ (PERCENT)
	0.00	3	4.8	4.8	4.8
	1.00	4	6.3	6.3	11.1
	2.00	4	6.3	6.3	17.5
	3.00	4	6.3	6.3	23.8
	4.00	2	3.2	3.2	27.0
	5.00	2	3.2	3.2	30.2
	6.00	1	1.6	1.6	31.7
	9.00	3	4.8	4.8	36.5
	10.00	3	4.8	4.8	41.3
	11.00	6	9.5	9.5	50.8
	12.00	1	1.6	1.6	52.4
	13.00	5	7.9	7.9	60.3
	14.00	1	1.6	1.6	61.9
	15.00	2	3.2	3.2	65.1
	17.00	1	1.6	1.6	66.7
	18.00	2	3.2	3.2	69.8
	19.00	2	3.2	3.2	73.0
GT 20 A LT 25	21.00	11	17.5	17.5	90.5
GT 25 PERCENT	22.00	6	9.5	9.5	100.0
	TOTAL	63	100.0	100.0	100.0

NOTE: Due to a change in caseload recording procedures during FY 76, data on DCAA, ENGINEERING, MANUFACTURING OPERATIONS, AND QUALITY CONTROL inputs are not included.

APPENDIX C

t TEST RESULTS OF FY 74-75 DATA

~~POPULATION SIZE = 291   DOLLAR VALUE CUTOFF = 500000.00~~

TOTAL DOLLAR VALUE OF POPULATION = 35117136.00

SAMPLE SIZE	ALPHA = .01 # PASSED	ALPHA = .01 % OF 100	ALPHA = .05 # PASSED	ALPHA = .05 % OF 100
10% -- 29	100	100.00	98	98.00
25% -- 72	100	100.00	99	99.00
30% -- 87	100	100.00	100	100.00
50% -- 145	100	100.00	100	100.00
60% -- 174	100	100.00	100	100.00
70% -- 203	100	100.00	100	100.00
75% -- 218	100	100.00	100	100.00

POPULATION SIZE = 172   DOLLAR VALUE CUTOFF = 100000.00

TOTAL DOLLAR VALUE OF POPULATION = 7259182.00

SAMPLE SIZE	ALPHA = .01 # PASSED	ALPHA = .01 % OF 100	ALPHA = .05 # PASSED	ALPHA = .05 % OF 100
10% -- 17	99	99.00	95	95.00
25% -- 43	99	99.00	98	98.00
30% -- 51	100	100.00	99	99.00
50% -- 86	100	100.00	100	100.00
60% -- 103	100	100.00	100	100.00
70% -- 120	100	100.00	100	100.00
75% -- 129	100	100.00	100	100.00

POPULATION SIZE = 341   DOLLAR VALUE CUTOFF = 1000000.00

TOTAL DOLLAR VALUE OF POPULATION = 72758667.02

SAMPLE SIZE	ALPHA = .01 # PASSED	ALPHA = .01 % OF 100	ALPHA = .05 # PASSED	ALPHA = .05 % OF 100
10% -- 34	95	95.00	92	92.00
25% -- 85	100	100.00	99	99.00
30% -- 102	100	100.00	99	99.00
50% -- 170	100	100.00	100	100.00
60% -- 204	100	100.00	100	100.00
70% -- 238	100	100.00	100	100.00
75% -- 255	100	100.00	100	100.00

APPENDIX D

t TEST RESULTS OF FY 76 DATA

POPULATION SIZE = 46 DOLLAR VALUE CUTOFF = 500000.00

TOTAL DOLLAR VALUE OF POPULATION = 6501537.00

SAMPLE SIZE	ALPHA = .01 # PASSED	% OF 100	ALPHA = .05 # PASSED	% OF 100
10% -- 4	92	92.00	84	84.00
25% -- 11	99	99.00	95	95.00
30% -- 13	100	100.00	97	97.00
50% -- 23	100	100.00	100	100.00
60% -- 27	100	100.00	100	100.00
70% -- 32	100	100.00	100	100.00
75% -- 34	100	100.00	100	100.00

POPULATION SIZE = 23 DOLLAR VALUE CUTOFF = 100000.00

TOTAL DOLLAR VALUE OF POPULATION = 1235106.00

SAMPLE SIZE	ALPHA = .01 # PASSED	% OF 100	ALPHA = .05 # PASSED	% OF 100
10% -- 2	87	87.00	73	73.00
25% -- 5	98	98.00	95	95.00
30% -- 6	100	100.00	99	99.00
50% -- 11	100	100.00	100	100.00
60% -- 13	100	100.00	100	100.00
70% -- 16	100	100.00	100	100.00
75% -- 17	100	100.00	100	100.00

POPULATION SIZE = 57 DOLLAR VALUE CUTOFF = 1000000.00

TOTAL DOLLAR VALUE OF POPULATION = 14432841.00

SAMPLE SIZE	ALPHA = .01 # PASSED	% OF 100	ALPHA = .05 # PASSED	% OF 100
10% -- 5	98	98.00	86	86.00
25% -- 14	100	100.00	97	97.00
30% -- 17	100	100.00	99	99.00
50% -- 28	100	100.00	100	100.00
60% -- 34	100	100.00	100	100.00
70% -- 39	100	100.00	100	100.00
75% -- 42	100	100.00	100	100.00

APPENDIX E

TTEST (07/09/76)

```
%CAPT ANSFLMI  DFEGM  FCC0679  TTEST  09JUL76
BEGIN
    FILE CR(KIND=READER),
         DK(KIND=DISK,TITLE="HUGHESDATA.",FILETYPE=7),
         LN(KIND=PRINTER,MAXRECSIZE=22);
    ARRAY DATA,SAMP,POP,PROP,RECOM,NEGOT[0:500];
    REAL PMEAN,PVAR,SMEAN,SVAR,T,TOTOOL,CUTOFF,SEFD,TAB01,TAB05;
    INTEGER PASS05,PASS01,PNO,SNO,TNO,I,SHI;
    LABEL EOFCR,EOFDK;
    VALUE ARRAY FRAC(.1,.25,.3,.5,.6,.7,.75,.8,.9),
                T01(0,63.657,9.925,5.841,4.604,4.032,
                    3.707,3.499,3.355,3.250,3.169,
                    3.106,3.055,3.012,2.977,2.947,
                    2.921,2.898,2.878,2.861,2.845,
                    2.831,2.819,2.807,2.797,2.757,
                    2.779,2.771,2.763,2.756,2.750),
                T05(0,12.706,4.303,3.182,2.776,2.571,
                    2.447,2.365,2.306,2.262,2.228,
                    2.201,2.179,2.160,2.145,2.131,
                    2.120,2.110,2.101,2.093,2.086,
                    2.080,2.074,2.069,2.064,2.060,
                    2.056,2.052,2.048,2.045,2.042);


    PROCEDURE MEANVAR(VECTOR,LENGTH,P);
                   VALUE LENGTH,P;
                   INTEGER LENGTH,P;
                   ARRAY VECTOR[0];
        BEGIN
            INTEGER I;
            REAL SUM,SSQ;
            FOR I:=0 STEP 1 UNTIL (LENGTH-1) DO BEGIN
                SUM:=*+VECTOR[I];
                SSQ:=*+(VECTOR[I]**2);
            END FOR I;
            SMEAN:=SUM/LENGTH;
            SVAR:=(SSQ-(LENGTH)*(SMEAN**2))/(LENGTH-1);
            IF P = 1 THEN BEGIN
                PMEAN:=SMEAN;
                PVAR:=SVAR;
            END IF P;
        END MEANVAR;


    PROCEDURE GETPOP;
        BEGIN
            INTEGER I,K;
            K:=-1;
            TOTOOL:=0;
            FOR I:=0 STEP 1 UNTIL TNO DO
                IF PROP[I] LEQ CUTOFF THEN BEGIN
                    POP[K:=*+1]:=DATA[I];
                    TOTOOL:=*+PROP[I];
            END IF PROP AND FOR I;
            PNO:=K;
        END GETPOP;


    PROCEDURE GETSAMP(LENGTH);
                   VALUE LENGTH;
                   INTEGER LENGTH;
        BEGIN
            INTEGER I,REC;
            ARRAY USED[0:1000];
            FOR I:=0 STEP 1 UNTIL LENGTH DO BEGIN
                DO
                    REC:=INTEGER((RANDOM(SEED)*1000.)
                UNTIL REC LEQ PNO AND USED[REC] = 0;
                SAMP[I]:=POP[REC];
                USED[REC]:=1;
            END FOR I;
        END GETSAMP;
```

```
PROCEDURE CALCT;
   BEGIN
      PASS05:=PASS01:=0;
      PHI:=PNO + SNO -2;
      IF PHI > 30 THEN BEGIN
         TAB01:=2.575;
         TAB05:=1.960;
      END            ELSE BEGIN
         TAB01:=T01[PHI];
         TAB05:=T05[PHI];
      END;
      THRU 100 DO BEGIN
         GETSAMP(SNO);
         MEANVAR(SAMP,(SNO+1),0);
         T:=ABS( (PMEAN-SMEAN)/SQRT( (PVAR/(PNO+1)) +
                                     (SVAR/(SNO+1))     ) );
         IF T LEQ TAB01 THEN BEGIN
            PASS01:=*+1;
             IF T LEQ TAB05 THEN
               PASS05:=*+1;
         END IF T;
      END THRU 100;
   END CALCT;


   SEED:=TIME(14);
   FOR TNO:=0 STEP 1 UNTIL 500 DO BEGIN
      READ(DK,<X6,2F8.0,X4,F8.0>,PROP[TNO],RECOM[TNO],
                                  NEGOT[TNO])[EOFDK];
      DATA[TNO]:=(PROP[TNO]-RECOM[TNO])/PROP[TNO];
   END FOR TNO;
EOFDK:
   WHILE TRUE DO BEGIN
      READ(CR,/,CUTOFF)[EOFCR];
      GETPOP;
      MEANVAR(POP,(PNO+1),1);
      WRITE(LN,<"POPULATION SIZE =",I4,X5,"DOLLAR VALUE ",
                 "CUTOFF =",F12.2//X3,"TOTAL DOLLAR VALUE ",
                 "OF POPULATION =",F14.2//X21,"ALPHA = .01",
                 X11,"ALPHA = .05"/" SAMPLE SIZE ",
                 2(X5,"# PASSED  % OF 100")/>,
         (PNO+1),CUTOFF,TOTDOL);
      FOR I:=0,1,2,3,4,5,6,7,8 DO BEGIN
         SNO:=(INTEGERT((PNO+1)*FRAC[I]))-1;
         CALCT;
         WRITE(LN,<I5,"% --",I4,2(I11,F10.2)/>,
              (FRAC[I]*100),(SNO+1),PASS01,PASS01,
              PASS05,PASS05);
      END FOR I;
      WRITE(LN,</////////>);
   END WHILE TRUE;
 EOFCR:
END.
```

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